iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 3 **Issue:** VII **Month of publication:** July 2015

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

On Associating SVC and DVB-T2 for Video Broadcasting

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Abstract: DVB-T2 is offering a new way for broadcasting value-added services, like HDTV and 3D TV, to either fix or mobile end users. DVB-T2 brings a new flexibility in services broadcasting with an increased transfer capacity of 50%, in contrast with the first generation of the DVB-T standard. On the other hand, SVC video coding is an emerging technique that uses scalability to encode video content in a hierarchical video streams (i.e. layers). Indeed, the SVC supports three types of video scalability: spatial, temporal and quality; which allow handling user's heterogeneity in term of capacity and bandwidth. To support SVC over DVB-T2 networks, associating the layering architecture of both technology, in order to tackle users mobility. This association allows mobile receivers with good physical channel to decode all the SVC layers and benefit from high video quality. Meanwhile, users with worst channel condition can at least decode the base layer and benefit from acceptable video quality.
Keywords: DVB-T2, SVC, Spatial scalability, temporal scalability, Quality scalability.

I. INTRODUCTION

DVB-T2 is the second generation standard for digital terrestrial television broadcasting. DVB-T2 brings a new flexibility in services broadcasting with an increased transfer capacity of 50%, when compared to the first generation of the terrestrial broadcasting standard (DVB-T) published in 1997. To allow a high robustness against multipath propagation, DVB-T2 uses a Coded Orthogonal Frequency Division Multiplexing (COFDM) multi-carrier modulation, in a similar way to DVB-T. A wider range of schemes is proposed, from 1K carrier up to 32K carrier, to meet the wide range's requirements of receiving equipments (i.e. fixed and mobile) and network topologies (i.e. single and multiple frequency networks). In terms of channel coding, DVB-T2 uses Low Density Parity Check (LDPC) block codes and Bose-Chaudhui Hochquenghene (BCH) coding, which Provide more robust error correction than the convolutional and Reed Solomon encoding used in DVB-T. Most of the capacity gain of DVB-T2 comes from this fundamental change of channel coding. The DVB-T2 physical layer data channel is divided into logical entities called the Physical Layer Pipes (PLP). Each PLP carries one logical data stream. Examples of such a logical data stream would be an audio-visual multimedia stream along with the associated signaling information, or an hierarchical application streams, which can address at the same time different qualities. The PLP architecture is designated to be flexible so that arbitrary adjustments of robustness and capacity can be easily done.Thus, using different PLP enable broadcasting, on a single radio channel, multiple services, or groups of services, with different channel coding and modulation settings. Broadcasting several service components over the same channel is thus made possible, with differentiated levels of robustness, which was not possible with the previous DVB-T standard. An example of using this new capability is to handle users' channel diversity. Indeed, users with good channel condition can decode all the PLPs, so they can receive high quality contents. Users with worst channel condition (such as mobile terminals), on the other hand, can decode only robust PLP and hence receive a lower service quality.

Scalable Video Coding (SVC), meanwhile, is a new coding technique that can manage, store, and distribute content towards multiple kinds and scales of terminals, and over different access technologies to reach the end user. The scalability in SVC is achieved by taking advantage of the layered approach already known from former video coding techniques. It is represented by three fundamental types of scalabilities: spatial, temporal, and quality. An SVC stream includes one base layer and one or several enhancement layers. The removal of an enhancement layer still lead to reasonable quality of the decoded video. The base layer is conforming to existing H.264/AVC profile, which ensures backward compatibility with existing receivers. Within SVC, Video Service Providers have the possibility to constitute a set of combinations of layers to create the SVC video streams. This will allow them to target different spatial as well as temporal scales depending on the users' conditions of reception. In this paper, we propose to associate the SVC video coding with DVB-T2 networks to provide efficient video broadcasting for the mobile receivers. In fact, it is obvious that hierarchical physical layers provided by DVB-T2 can be easily combined with hierarchical video coding feature proposed by SVC.

Each SVC layer is broadcasted through a particular PLP. The base layer is sent through the most robust PLP, usually PLP0. The enhancement layers are sent through other PLPs, which use less robust physical modulation while allow using more data rate. Thus, mobile station with good physical channel can decode all the layers and benefit from high video quality. Meanwhile, users with worst channel condition can at least decode the base layer and benefit from acceptable quality.

II. SCALABLE VIDEO CODING

In general, a video bit stream is called scalable when parts of the stream can be removed in a way that the resulting sub stream forms another valid bit stream for some target decoder, and the sub stream represents the source content with a reconstruction quality that is less than that of the complete original bit stream but is high when considering the lower quantity of remaining data. Bit streams that do not provide this property are referred to as single-layer bit streams. The usual modes of scalability are temporal, spatial, and quality scalability. Spatial scalability and temporal scalability describe cases in which subsets of the bit stream represent the source content with a reduced picture size(spatial resolution) or frame rate (temporal resolution), respectively. With quality scalability, the sub stream provides the same spatio–temporal resolution as the complete bit stream, but with a lower fidelity—where fidelity is often informally referred to as signal-to-noise ratio (SNR). Quality scalability is also commonly referred to as fidelity or SNR scalability. More rarely required scalability modes are region-of-interest (ROI) and object-based scalability, in which the sub streams typically represent spatially contiguous regions of the original picture area. The different types of scalability can also be combined, so that a multitude of representations with different spatiotemporal resolutions and bit rates can be supported within a single scalable bit stream.
Efficient SVC provides a number of benefits in terms of applications -a few of which will be briefly discussed in the following. Consider, for instance, the scenario of a video transmission service with heterogeneous clients, where multiple bit streams of the same source content differing in coded picture size, frame rate, and bit rate should be provided simultaneously. With the application of a properly configured SVC scheme, the source content has to be encoded only once—for the highest required resolution and bit rate, resulting in a scalable bit stream from which representations with lower resolution and/or quality can be obtained by discarding selected data. For instance, a client with restricted resources (display resolution, processing power, or battery power) needs to decode only a part of the delivered bit stream. Similarly, in a multicast scenario, terminals with different capabilities can be served by a single scalable bit stream. In an alternative scenario, an existing video format (likeQVGA) can be extended in a backward compatible way by an enhancement video format (like VGA).Another benefit of SVC is that a scalable bit stream usually contains parts with different importance in terms of decoded video quality. This property in conjunction with unequal error protection is especially useful in any transmission scenario with unpredictable throughput variations and/or relatively high packet loss rates. By using a stronger protection of the more important information, error resilience with graceful degradation can be achieved up to a certain degree of transmission errors. Media-Aware Network Elements (MANEs), which receive feedback messages about the terminal capabilities and/or channel conditions, can remove the non required parts from a scalable bit stream, before forwarding it. Thus, the loss of important transmission units due to congestion can be avoided and the overall error robustness of the video transmission service can be substantially improved.
SVC is also highly desirable for surveillance applications, in which video sources not only need to be viewed on multiple devices ranging from high-definition monitors to videophones or PDAs, but also need to be stored and archived. With SVC, for instance, high-resolution/high-quality parts of a bit stream can ordinarily be deleted after some expiration time, so that only low-quality copies of the video are kept for long-term archival. Scalable Video Coding (SVC) is a highly attractive solution to the problems posed by the characteristics of modern video transmission systems. The objective of the SVC standardization has been to enable the encoding of a high-quality video bit stream that contains one or more subset bit streams that can themselves be decoded with a complexity and reconstruction quality similar to that achieved using the existing H.264/AVC design with the same quantity of data as in the subset bit stream The latter approach may also become an interesting feature in personal video recorders and home networking. Even though SVC schemes offer such a variety of valuable functionalities, the scalable profiles of existing standards have rarely been used in the past, mainly because spatial and quality scalability have historically come at the price of increased decoder complexity and significantly decreased coding efficiency.

In contrast to that, temporal scalability is often supported, e.g., in H.264/AVC-based applications, but mainly because it comes along with a substantial coding efficiency improvement. In any case, the coding efficiency of scalable coding should be clearly superior to that of "simulcasting" the supported spatio–temporal resolutions and bit rates in separate bit streams. In comparison to single-layer coding, bit rate increases of 10% to 50% for the same fidelity might be tolerable depending on the specific needs of an application and the supported degree of scalability. The SVC design also supports the creation of quality scalable bit streams that can be converted into bit streams that conform to one of the non scalable H.264/AVC profiles by using a low-complexity rewriting process. For this mode of quality scalability, the same syntax as for CGS or MGS is used, but two aspects of the decoding process are modified.

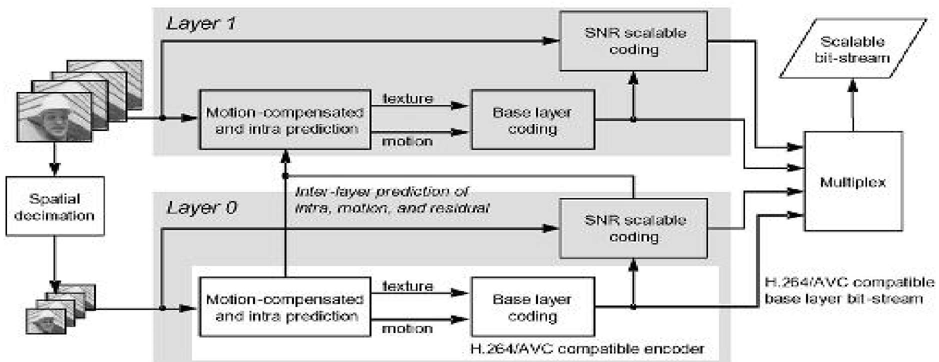

Fig.1.SVC Encoder structure

For the inter-layer intra-prediction, the prediction signal is not formed by the reconstructed intra-signal of the reference layer, but instead the spatial intra-prediction modes are inferred from the co-located reference layer blocks, and a spatial intra-prediction as in single-layer H.264/AVC coding is performed in the target layer, i.e., the highest quality refinement layer that is decoded for a picture. Additionally, the residual signal is predicted as for motion-compensated macro block types. The residual prediction for inter-coded macro blocks and for inter-layer intra-coded macro blocks (base mode flag is equal to 1 and the co-located reference layer blocks are intra-coded) is performed in the transform coefficient level domain, i.e., not the scaled transform coefficients, but the quantization levels for transform coefficients are scaled and accumulated. These two modifications ensure that such a quality scalable bit stream can be converted into a non scalable H.264/AVC bit Stream that yields exactly the same decoding result as the quality scalable SVC bit stream. The conversion can be achieved by a rewriting process which is significantly less complex than transcoding the SVC bit stream. The usage of the modified decoding process in terms of inter-layer prediction is signaled by a flag in the slice header of the enhancement layer slices. SVC additionally provides means by which the sub streams that are contained in a complete scalable bit stream can be easily identified. An SVC bit stream does not need to provide all types of scalability. Since the support of quality and spatial scalability usually comes along with a loss in coding efficiency relative to single-layer coding, the trade off between coding efficiency and the provided degree of scalability can be adjusted according to the needs of an application.

III. SIMULATION RESULTS

We simulated video broadcast for mobile stations. We considered three scenarios (mobile speed): pedestrian 1m/s, city car 50km/h and urban car 110km/h. Regarding the DVB-T2 networks, we considered three PLPs. PLP0, PLP1 and PLP2 convey, respectively, the base layer, the enhanced layer 1 and the enhanced layer 2. The antenna height used by the DVB-T2 gateway is 210m, and those used by the mobiles are 1m for Pedestrian scenario and 2m for the other scenarios.

	Physical rate	Modulation	Frequency
PLP0	7.5 Mbps	16 QAM ½	622 Mhz

Volume 3 Issue VII, July 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

PLP1	21.1 Mbps	64 QAM 3/5	622 Mhz
PLP2	34.24 Mbps	256 QAM 3/5	622 Mhz

Table 1: DVB-T2 Parameters

In addition, we added the possibility to simulate fading power envelop channel by using Rician or Rayleigh models. These models are widely used to simulate multipath models for mobile communications where one or both communicating terminals are mobile and where the terminals are using wide-angle or omnidirectional antennas. We recall that Rician model is used for Line-Of-Sight (LOS) communication, which depend on them signal strength of the LOS component k, and Rayleigh (k = 0) is used for No LOS communication. Table I gives an overview of the DVB-T2 parameters used in the simulation. The video scalability is based on quality (CGS) enhancement. The corresponding QP for base layer, enhanced layer 1 and enhanced layer 2, are 48, 33 and 15, respectively. The IDR period is 16, and the frame rate is 30 frames per second. The spatial resolution is 352 x 288.

The first results we present in this section are related to the physical signal quality in term of Bit Error Rate (BER).Figures 2, 3, 4, 5, 6 and 7show the BER versus the simulated time (600 seconds) for Pedestrian, City Car and Urban Car scenarios. For each scenario, we present the results for Rayleigh and Rician channels. Here, to reflect user mobility on multipath signal, we increased the Max Velocity (Doppler Frequency) parameter of both channel models.

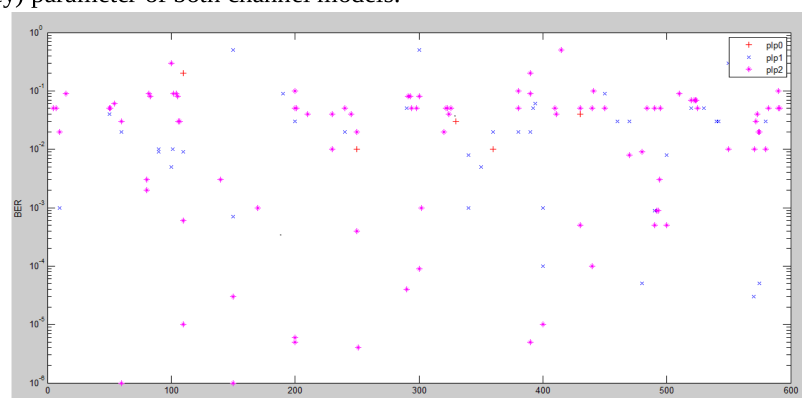

Fig. 2. BER vs Time - Pedestrian Rayleigh channel

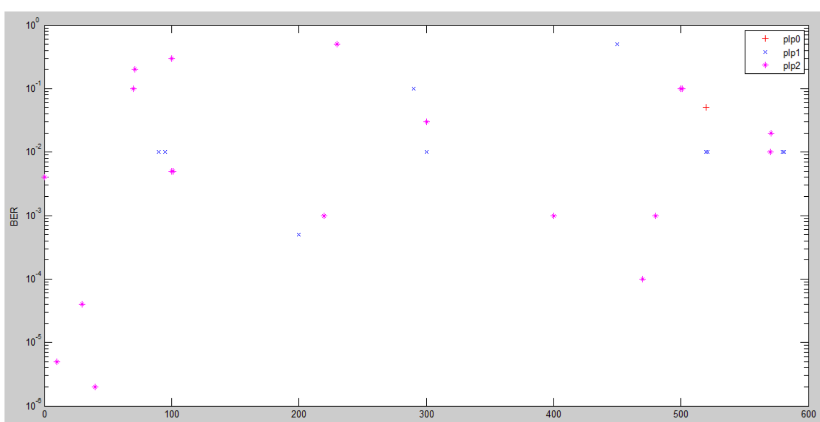

Fig. 3. BER vs Time - Pedestrian Rician channel

Volume 3 Issue VII, July 2015
ISSN: 2321-9653

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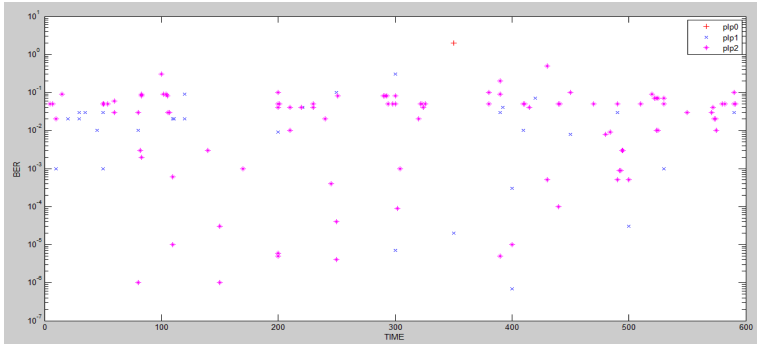

Fig. 4. BER vs Time - Urban Car Rayleigh channel

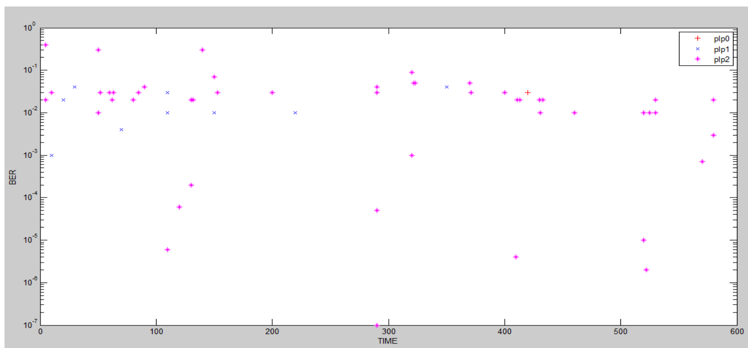

Fig. 5. BER vs Time - Urban Car Rician channel

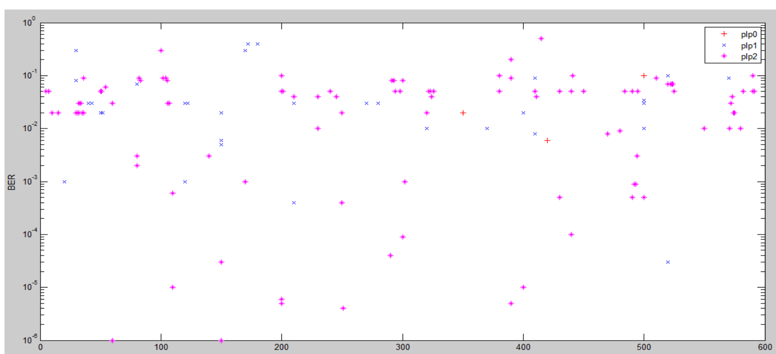

Fig. 6. BER vs Time - City Car Rayleigh channel

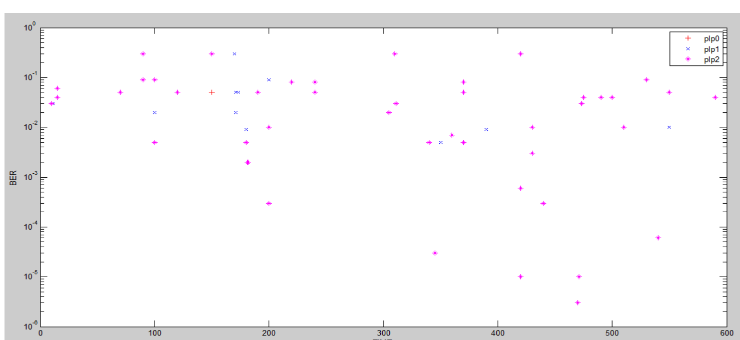

Fig. 7. BER vs Time - City Car Rician channel

From these figures we see that the BER in Rayleigh channel is higher than in Rician channel (for all scenarios). This is logical as Rayleigh envelop does not contain a LOS component, hanging more frequently, as the high Max Velocity of objects around mobile user degrades the received SNR. However, we notice that Pedestrian scenario shows higher BER than City Car, since the antennas height is different. In case of Pedestrian scenario the antenna height (1m) is smaller than the City Car scenario (2m). Furthermore, we can clearly see from these figures that PLP1 and PLP2 are less robust than PLP0, since they use less robust modulation and less FEC protection than PLP0. These results show clearly the advantages of associating SVC with DVB-T2 for mobile users, since in most of the cases PLP0 layer is correctly received (i.e. the video base layer).

IV. CONCLUSION

We proposed an association of SVC video coding with DVB-T2 broadcasting to address the challenges related to the good support of Mobile TV. Despite of the enhancements achieved by this association, which allows mobile users with good channel condition to decode all the video layers and benefit from high video quality. The users with worst channel condition at least decode the base layer and benefit from acceptable video quality. For future works, we will extend our solution to address high quality contents, like 3D and HD in the context of SVC transmission over DVB-T2.

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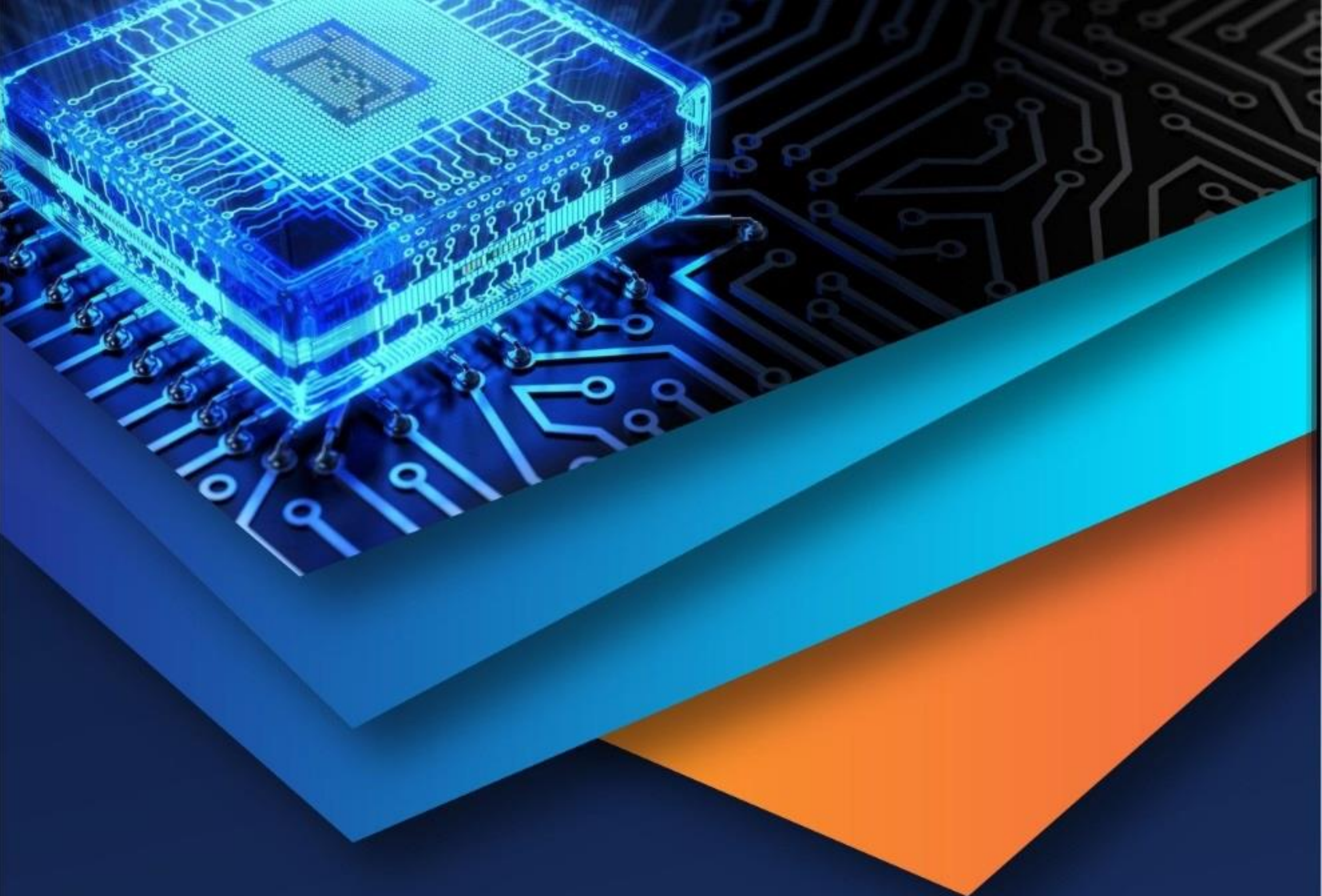

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